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ABSTRACT

This paper addresses issues and cost benefits of World Wide Web-based education systems. It presents the results of an effort to identify problems that arise when considering this media and suggests conceptual solutions to some of these problems. To evaluate these solutions, a prototype system was built and tested in an engineering classroom; the system was used to test the knowledge transfer and attitude of students as compared to the traditional classroom system. The primary conclusion was that the Web-based system resulted in significantly better learning as measured by an average of 10 more points on a 75-point quiz. Students working with the Web-based system spent more time studying the subject, which did affect their performance; however, a regression analysis showed that students using the traditional method improved their grade more per hours of study than did students using the Web method. Three figures illustrate the course assignment/team-communication page, course homepage, and course presentation page. (AEF)

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WEB-BASED EDUCATIONAL MEDIA: ISSUES AND EMPIRICAL TEST OF LEARNING

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Abstract: Web-based educational media are being developed rapidly and the pressure to employ this technology for distance learning is growing. Educators are rightfully asking questions regarding the cost/benefit of such efforts and how authors might deal with expected problems when employing such an open media. More basic research into these questions is needed. This paper attempts to shed some light in this regard. The results of an effort to identify problems that arise when considering this media are presented. Conceptual solutions to some of these problems are suggested. To test the concept, a prototype system was built and tested in an engineering classroom and the educational results of that test are presented. The research effort reported here was, in part, funded by the National Science Foundation.

Significance

Paper presents concept and empirical results that can contribute to the improved design of Web-based distance learning media.

1. INTRODUCTION

The low operating requirement and great potential audience for Web-based educational delivery has generated great interest in this technology. A few years ago, one could find only experimental courses typically built by computer science faculty. Today courses at all levels of education in many fields are being reported. In the Western U.S., an initiative to create an "open university" wherein students from several Rocky Mountain States will be able to attend courses at several universities has been established by those state's respective governors. Web-based distance learning systems are a big technological wave that is fast approaching.

Yet there are many unanswered questions regarding Web-based educational systems. The primary question is, whether the student can learn as well using this technology as when taking courses in the traditional classroom. A highly related question is the potential number of added student that can be reached through distance learning. A third question is the relative magnitude of development and maintenance costs as well as delivery costs when using such course systems. Technical questions arise regarding the protection of intellectual property rights including the broadcasting of copyrighted materials. Answers to these and other questions are needed as these system begin the move into the mainstream of education.

This paper is one small attempt to contribute to the body of information regarding the issues and cost/benefits of Web-based education systems. The results of an effort to identify problems that arise when considering this media are presented. Conceptual solutions to some of these problems are suggested. To test these solutions, a prototype system was built and tested in an engineering classroom and the educational results of that test are presented.

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2. ISSUES WITH WEB-BASED EDUCATIONAL MEDIA

There are a number of issues involved with web based educational media. Some of them are hurdles or delimiters in this new concept, whereas there are others, which encourage usage of this media to transport education. The next few paragraphs describe the issues involved with developing and using such a system.

2.1 Favorable aspects of web based educational systems:

These are a growing number of web authoring tools which help in developing courseware for the web. The advantage is that the user need not know anything about HTML or other programming languages, and the entire task of placing the courseware on the web in an orderly fashion is accomplished by the tool itself. An example of an authoring tool is HCC(HTML Course Creator) which allows instructors who are not HTML experts to rapidly develop and easily maintain consistent libraries. The course can be tailored to specify styles based on templates to cater to various types of courses. Using tools like HCC instructors from different backgrounds can create and maintain network hypermedia courses accessible over the web.[Carver 1996].

Research is going on to address the security issues in the sale and distribution of information over the Internet. IBM infomarket is a new network based service offering from IBM that will allow digital publishers to sell their content over the web. This service will support the secure distribution of intellectual property to limitless number of "downstream" consumers over electronic networks, while providing a mechanism for the copyright holder to receive payment for each use of the subject matter. This technology will encourage more and more authors to have their writings on the web.[Crigler 1996]

Another crucial advantage of web based systems is the role they play in long distance education. Since the course is on the web, it can have a very large audience. This also means that the system can be made cost efficient and there is scope for improvement. With multimedia technologies developing so rapidly a multimedia approach requires a whole new approach to the learning process. Multimedia, e-mail and online quizzes all packed together in the system revolutionizes the whole concept of Distance Education giving it a new definition.

Having a course on the web, directly places a student in a computer environment. This give the student direct access to many other software tools like search engines, word processors and spreadsheets which are often required to do assignments. In this way it offers many indirect benefits.

2.2 Problematic aspects of these educational systems:

The web based educational system has to be evaluated before any large-scale implementation is carried out. A good evaluation of the effectiveness of this system will come as more and more faculty make use of it and report their experiences to their peers and administrators. In one particular case the faculty member offered two sections of the course one taught through traditional lecture means and the other taught by using the WWW in all facets of course work. In the traditional set-up students were distributed materials or pointed to libraries, they wrote their reports with word processors and gave in reviews of their research. In the web based section students were directed to readings on-line and library resources. All student research and reports were put together and delivered on the web. Students using the web-based system were also able to collaborate partially. For both classes the average grade was 'B', but most effective feedback came from the students themselves. In the web based class students felt they invested more time in projects, had a steeper learning curve, the collaborative process was fruitful and the sense of accomplishment was greater.[Ellen et al. 1995].

Developing an entire course is still an expensive affair. Authoring tools are still immature and often too generic. The HTML converter tools for example are not very efficient. Thus the instructor is forced to learn more about the web. This may discourage the faculty in developing their courses for the web. Also putting courses on the web is a long process, especially if one wants to make it interactive with a lot of multimedia features. One also needs an expensive digitizer to convert analog video signals to digital format to store it in a disk. But these issues are being addressed and one can expect more tools in the future, which are less expensive.

Copyright issues of documents placed on the web are not settled. The security features that are available will not prevent a student from making multiple copies of a document and distributing it. This aspect of the web will discourage many authors from putting their works on the web. Employing tools such as IBM's infomarket, some solutions are available, but questions on how one could incorporate these features are still unanswered.

When using the web, one very important issue is that the presentation of the course material should be far superior to how it is currently done with overhead projectors or for that matter with textbooks. The web-based system should be highly interactive and should incorporate lot of multimedia features, which can give the learning environment a new and refreshing flavor.

The Internet is still a very slow communication medium. Internet access by students outside the university campus is typically frustrating because the current data transfer rates are very low. Also the processor speed on the client machine makes quite a difference. A slow processor can greatly increase the time to display images. Therefore the web is still not suitable for big files with many images or graphics. However, it is suitable for text materials.

Today, students do not have sufficient access to computers and many students have no computer at home. This factor can web based education more expensive for students and is very discouraging in developing web-based courses. When one is dependent on someone or something else it makes learning a less interesting process. The cost of a computer with the required configuration is quite high.

3. CONCEPTUAL DESIGN OF A WEB-BASED EDUCATIONAL SYSTEM

The solutions to problems suggested in section-2 will require technical concepts similar to those developed in an National Science Foundation funded project to connect product design teams to each other and wide varieties of proprietary design data [Bailey]. In this section we shall describe a conceptual design and first prototype of a system for Web-based education which offers solutions. Much work is needed for such a system to be completely available in its totality.

3.1 Functional Requirements

- Easy and low cost transfer of existing course materials.
- Easy and low cost development of new materials.
- Timely media-based feedback to students.
- Automatic customization of materials to students.
- Support of various learning styles through multimedia.
- Easy communication to instructors of fellow students.
- Easy links to search engines and course related literature.
- Fast transfer of picture and video material.
- Difficult t to copy or otherwise share material.
- Time management capability to help students schedule.
- Easy access to appropriate learning support tools.

3.2 Conceptual Solution

The objective of the research reported here was to build a web-based system that provides some of the required functionality and then to test the ability of that system to improve the education process a broad conceptual design was designed. The test system was developed with locally stored pictures and videos. The system provided the student with point and click access to word processing and spreadsheet tools.

The system involves the usage of a web server to deliver part of course module over the web with video and graphics supplied from a CD-ROM. When a student in/off campus registers for the course, he/she is provided with a CD-ROM, a manual to use the package and other course material. The client can only view the course from a popular browser like Netscape3.0 or above. Some of the course material is delivered from a web server over the net, whereas most of the video files and other long files are read from the CD-ROM, within the browser environment. The student can also register for the course on-line over the web. The student is then provided with a user_id and password by which he can access the course homepage. The student is also sent a CD-ROM and related material by mail.

All details about the student, quizzes and grades are stored in a database. The text material and any updates or changes in the course are delivered from the web server. The web server maintains the connections to the database server. Having database storage also gives a lot of flexibility in designing the course to cater to a wider

group of students. Each student's course profile (the course structure varies from student to student giving him an opportunity to select a course which more closely fits his requirement or interests) is stored in the database, and when the student accesses the course over the web, the course delivered is tailored to that student's background. For example, electrical engineering students would receive different examples than mechanical engineering students.

There is also an IRC or chat server. Students registered for the course can discuss about the course with their classmates. It also allows the instructor to talk to the students once in a while and answer their queries immediately. This feature partially covers the sociability aspects, which is an important element in a typical classroom environment.

The course also has a search engine with predefined bookmarks to get course-related information from the web. Thereby the web server behaves as a online library and a suitable medium to gather more information on the subject. The search engine can also serve as a quick index for the course material.

Basically the system gives a student the facility of being able to sit in one place and do everything, read about the course, take virtual classes, do assignments, discuss the course with his classmates and even answer the tests. One issue not talked about in the system is how the course material is going to be developed and cost analysis of the system.

3.3 Prototype Test System

The prototype system built to test the suggested concepts consisted of two major components: a course-assignment/team-communication sub-system and a lecture-delivery sub-system. These sub-systems were integrated and delivered via Netscape. The system employed a Sun Solaris university server connected to ASU's student network. The reader can access the system via URL: www.eas.asu.edu/~ece300/.

The home page for the system contained HTML buttons or links to access information about the course, instructor, and a real time grade status reporter. The first two pages were open to all users but the last button activated a Java program that access the gradebook database using a PIN number. Thus students had access to only their own grade data. The home page also allowed access to the course-assignment/team-communication and lecture-delivery subsystems.

The course-assignment/team-communication page as illustrated in Exhibit-1 permits any student to highlight any team including his/her own and any team or individual-assignment assigned to his/her PIN number. When a team is highlighted, the members of that team are displayed and the assignments file IDs associated with that team are instantiated. The student can highlight any sub-set of team members and activate an E-mail package. In this way, team members can communicate with each other, the instructor and industrial term project

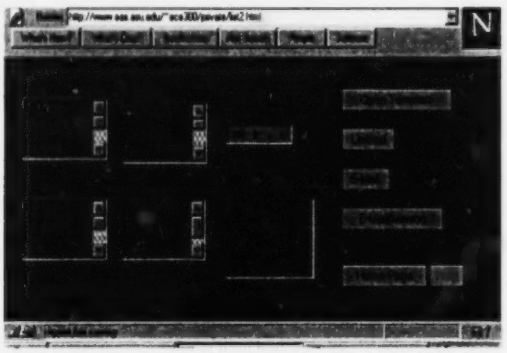

Exhibit 1:
Course assignment
/Team-communication
page

client/mentors. They can also highlight any assignment for which they have PIN-number access authorization and open application software package with the appropriate document. For example, through Microsoft-office, they can access reports in Word or spreadsheet models in Excel. The most recent version copy of the document will come up on their computer. Several problems exist. The student's computer must have the application software on their system. One has to have Netscape3.0 or higher and Windows 95 as the browser has to be Java enabled and should support JavaScript. In addition data concurrency is problematic since more than one

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copy of any file can be active. In any case, the student can be given read-only access or read-write access to any output assigned to him/her or to the team.

The lecture homepage is illustrated as Exhibit-2 permits the student to attend any electronic lecture on the system. A list of available lecture topics is given; for the test prototype, only one lecture module was generated. Upon highlighting a lecture the student starts by bringing up a set of detailed lecture notes. These notes are generated to cover what the instructor believes to be a non-reducible concept as illustrated in Exhibit-3. Present experience suggests that a typical 50-minute lecture would translate into between 5 and 10 concepts. The level of detail, in these notes, is sufficient for a student, familiar with the material, to review the issue.

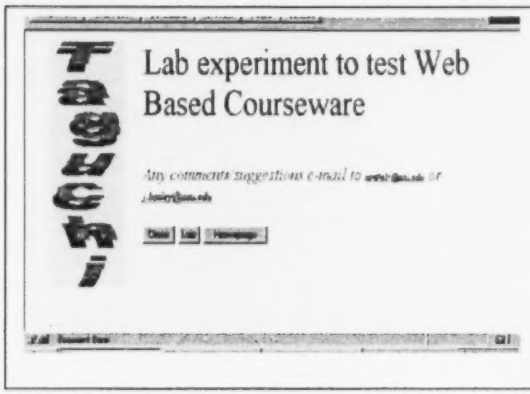

Exhibit 2: Course homepage

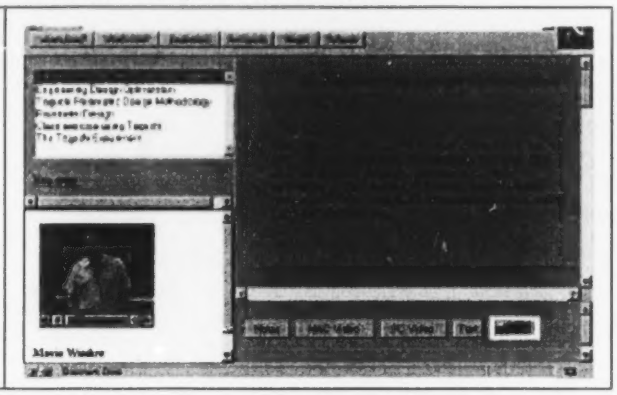

Exhibit 3: Course Presentation

Three HTML buttons are available for each issue: a text button, a video-lecture button, and a quiz button. Clicking the text button delivers a window containing a textbook level written discussion about the issue. These notes reside on the CD-ROM that the student purchased so the material is viewed from a web browser only. However, while the student's PIN number is active, he/she may access the text material from the web server as often as desired. The video-lecture button to the student delivers a videotaped lecture stored in the CD-ROM. Here too, the video is difficult to copy but can be viewed often. Finally, a quiz button when clicked delivers a computer graded practice quiz to the screen. A random subset of computer gradeable questions is printed allowing the student to test his understanding. Upon completion, the computer will grade the quiz and announce the score. The student can than decide if they need to spend more time on the topic or go to the next module. All these sub-pages have buttons to return to the lecture note.

4. PILOT TEST OF A WEB BASED EDUCATIONAL SYSTEM

Conducting such a sophisticated study that compares two different sorts of course environments to find if one is "better" than the other is practically impossible. What need's to be done is specify certain conditions and compare aspects of one environment to parallel aspects of the other environment. But either so, one will not get a simple-to-interpret answer of "is a better than b?"[Collis 1997] If the test is conducted in the real world, due to gross differences in the types of courses and other environmental factors, even a reasonably accurate assessment of the system is doubtful. To avoid some of these problems the test is conducted in a lab environment with preset parameters, and any discrepancies in evaluation due heterogeneity of the students in the system can be washed away by statistical techniques. But the only drawback with such a approach is that students tend to be conscious of being part of an experiment and may tend to behave in a less natural manner, which may affect the final result. A lab based approach to evaluate the educational system is described below.

The prototype system described above was used to test the knowledge transfer and attitude of students as compared to the traditional classroom system. Two hypotheses were tested:

Ho(1): The amount of learning via the Web-based system is no better than that of the traditional face-to-face delivery system.

Ho(2): The students attitudinal reaction to the Web-based system is no better than toward the traditional face-to-face delivery mechanism.

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These two hypotheses were to be tested empirically and if both are rejected, we could conclude that a Web-based educational delivery system was shown in this case to be superior to the traditional system. Because these results are not available as this paper is written but will be available before the paper is presented, they are not presented in the paper but will be included in the Toronto meeting.

The test scenario was an one week engineering course module covering the Taguchi method for establishing robust design parameters. The text, notes, and lecture materials were adapted and delivered by the research advisor co-author of this paper. Two classes of 35 students in Arizona State University's Engineering ECE-300 were used as test subjects. The test was run in the same week of April 1997. The module consisted of one 50-minute lecture covering the Taguchi methodology, a 50 minute laboratory exercise in which the student collect data and analyzed the parameters of a toy catapult, a 15 minute quiz taken manually by both sets of students, and an attitude questionnaire. Attitude was measured using the semantic differential technique (x)[Bailey 1983]. The test data was, therefore, the quiz scores and the attitude scores.

Demographics for the students were collected and scores adjusted to account for potentially affective differences in the two test populations. The student's ages were assessed as a surrogate for maturity, which might affect attitude and performance. Class standing data, in terms of credit hours taken as a surrogate for the added experience more advanced students would bring to the test. Three times the number of credit hours being taken plus the hours being worked per week were measured as a surrogate for the time a student would have available for study. Finally, the students' grade point average was collected as a surrogate for the students' intelligence and seriousness toward school.

The primary conclusion was that the Web based system resulted in significantly better learning as measured by an average of 10 more points on a 75 point quiz. The greatest increase was for questions that came from instructor provided class notes. The study was unable to reject the hypothesis that the students reaction to the experience was any different between the two systems except that students preferred the hands-on laboratory exercise over its computer simulation. None of the demographic factors: age, GPA, or credit hours affected these conclusions. Finally, students working with the Web based system spent more time studying the subject, which did affect their performance. However a regression analysis showed that students using the traditional method improved their grade more per hours of study (2.18 to .75 points/hour) than did students using the web method.

5. CONCLUSION

The paper began by giving an overall picture in implementing a Web based educational media. The various issues in moving towards a web based educational media were also discussed. A list of requirements for a web-based system was enlisted and a conceptual system was proposed which aims at satisfying most of these. A prototype system developed and implemented was discussed. Finally, an evaluation methodology for a system just developed and the results of the experiment was given comparing the web-based system and traditional classroom

The whole world is moving in the direction of computers and Internet, and we are in the threshold of an Information Revolution, unparalleled even with the advent of the television and the telephone. Sooner or later like many other fields in life, even Educational styles have to shed some of there traditions and jump into the Internet bandwagon if it has to keep pace with changing technologies and lifestyles. With current technology limitations matters don't seem to be all that favorable for a web based system but it is definitely going be the solution in the near future. Does this mark the doom of the traditional classroom?

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